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Full Length Article

Lean constructions barriers in Jordan's building sub-sector: A comprehensive knowledge framework

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ABSTRACT

Lean Construction (LC) is a managerial approach to tackle productivity concerns. Minimize waste and address prevalent challenges in the construction industry. Despite that, this approach is still fresh in developing countries. This research aims to explore the barriers to LC implementation in the Jordanian building sub-sector, and develop a suggested framework that helps to connect these barriers. To achieve these objectives, 27 barriers were extracted from the literature review and modified based on academic professionals' opinions. The research methodology depends on the quantitative approach, where these barriers form the content of a questionnaire survey distributed to Jordanian building professionals; a total of 207 responses were returned and analyzed by different statistical analyses: Mann-Whitney U, Principal Component Analysis (PCA), and Linear Regression. The results indicated that the building professionals in Jordan needed a higher awareness and knowledge of the LC. Furthermore, the main finding of this research demonstrates that knowledge barriers are the ones preventing the implementation of LC in the Jordanian building sub-sector; these barriers are: lack of training in LC, lack of knowledge of LC concepts, and lack of knowledge about LC implementation. In addition, the remaining barriers were grouped into three groups based on PCA results: government, attitude, and resource. Moreover, the results include a suggested knowledge framework that helps overcome the knowledge barriers after studying the connection between them and the other groups of barriers.

1. Introduction

Building construction as a sub-sector of the construction industry plays an essential role in promoting the growth of any country, as it significantly impacts economic expansion due to its role in creating profitable investments [1,2], and its ability to reduce unemployment by providing a variety of job opportunities [2,3]. These benefits, along with others, enhance the growth rate in this sub-sector and direct the construction industry towards the so-called construction 4.0 [4]. Nevertheless, waste, lack of coordination, poor planning, resistance to change, and inadequate processes with unclear responsibilities continue to trouble building construction [5].

To give answers to these issues, new managerial and technical strategies were needed. In this regard, Lean Construction (LC henceforth) was created as the application and adaptation of the underlying concepts and principles of the Toyota Production System (TPS) to the construction industry to work on reduction in waste, increase in value to the customer, and promote continuous improvement [6]

1.1. Problem Statement

In Jordan, the construction industry has grown in recent years to become a more key industry in its magnitude and scope [6,7], growing from 3.8% to 4.1% in 2021 after the recovery from the COVID-19 pandemic [8]. Despite this, this industry encounters specific challenges, such as delays, ambiguity in regulatory requirements, slow adoption of innovative technology, and poor management. These challenges may be due to population growth, fluctuations, and political instability in neighboring countries, and this leads to the need to strengthen the industry and implement new managerial practices such as LC [9]. LC enhances the relationships between project stakeholders by developing coordination and communication among them throughout all the project phases [10]. LC also seeks to improve efficiency and productivity, develop management and reduce waste to simplify processes, use suitable resources accurately, and complete the projects within the time and cost limits [11]. Despite the widespread use of LC concepts, it remains a challenge, particularly in countries with

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developing economies [12]. As one of these countries, Jordan must eliminate numerous barriers in its construction industry to implement LC effectively and successfully [13].

1.2. Knowledge gap and research goal

Several authors have conducted studies on LC within the Jordanian construction industry, identifying obstacles and discovering the Jordanian construction professionals' opinions regarding it [13], evaluating implementation in specific construction companies [9,14], and examining BIM-Lean integration [15]. Despite these efforts, a noticeable gap exists in defining a comprehensive framework for implementing LC that considers barriers holistically in the Jordanian building sub-sector.

Jordanian companies must adopt a strategy to overcome barriers and take the first step towards implementing LC, as Al Balkhy [13] suggested. Therefore, it is worth extending the studies of the barriers to LC implementation in the specific building sub-sector and employing these barriers in a theoretical framework. Following this line, this research focuses on the Jordanian building sub-sector as a subset of the country's construction industry. It aims to identify the main barriers to implementing LC in the Jordanian building sub-sector (GOAL no. 1) and to define a theoretical framework based on them (GOAL no. 2). Through achieving these two objectives, valuable knowledge can be obtained to design rational strategies that enhance LC practices in the Jordanian building sub-sector.

1.3. Organization of the Paper

After introducing the problem statement, the knowledge gap and research goal, the second section reviews the relevant literature. Next, the research method is explained, outlining the steps to collect and analyze data. Section four encompasses the analysis of the collected data and shows the results of this research. Then, in section five, the results are compared with prior research, and the suggested framework is presented. The last section discusses the theoretical and practical significance of the results, as well as the limitations and suggestions for future studies.

2. Literature Review

2.1. Lean Construction

LC is an innovative approach for efficiently managing and delivering construction projects [16]. During the last thirty years, numerous studies have analyzed the benefits of LC implementation and what barriers hold back its implementation [17,18]. Womack and Jones emphasized five lean principles that may be considered a foundation for lean thinking: (1) identifying value through realizing what customers consider necessary; (2) eliminating any process or activity that does not contribute value; (3) building an easy and continuous workflow; (4) encouraging and enhancing collaboration and empowerment of project participants; and (5) continuous improvement [19]. These principles are also applicable to the construction industry and can lead to several benefits, such as eliminating waste, reducing costs, and improving sustainability [18,20].

Additionally, LC helps to decrease the lead time by depending on communication and collaboration among the stakeholders throughout the project lifecycle [21]. The benefits of implementing LC have been widely emphasized in various countries across the world [9,10].The United States of America, the United Kingdom, and Brazil are just a few examples of countries where the administrative approach to LC has proven successful [9,22]. It is undeniable that LC has many benefits. However, it is still challenging to successfully implement it in the construction industry [23–26].

2.2. Barriers to Lean Construction

Applying LC tools and techniques in the construction industry is complex, mainly because it establishes a link between traditional and lean practices[27]. In this regard, numerous authors have highlighted the main barriers that can influence lean implementation in the construction industry and stated that introducing LC requires overcoming the resistance to change from different participants in the construction industry [25,28,29]. Furthermore, it is recognized that there are not enough endeavors to help employees understand LC concepts, principles, and methodologies [30]. On the other hand, accepting LC knowledge requires a shift in project management techniques and the mindset of employees [31].

However, a lack of training and education, particularly in LC, increases this knowledge gap [13]. Similarly, a study in Peru emphasized that many construction specialists need to become more familiar with LC concepts, which is essential for them to fully understand the potential benefits or how to implement them effectively [32]. In line with this, Simonsen et al, 2023 analyzed the recent studies about the LC and observed that the lack of knowledge and understanding of the LC appeared in 59% of the studies analyzed [20]; additionally, most of these studies classified this barrier as challenging to overcome [9].

Besides that, a skilled and knowledgeable workforce is required to define waste and improve the overall process efficiency; however, without these crucial skills and education, it can be challenging to grasp LC concepts [30].

Different challenges to LC implementation were categorized into three groups. The first group was based on people-related barriers, occupying 29% of the barriers, which include education, operation, and culture. The second was related to the production process, with 20% of the barriers including management, planning, and control in the production process. The third was related to logistic barriers, with 51% including government and long-term business mindset [32].

On the other hand, the fragmented and complex nature of the construction industry brings additional challenges to implementing LC [33]. Construction projects often involve several related parties, including architects, different engineers, contractors, subcontractors, and suppliers; each has its own priorities and objectives [34,35]. Coordination and aligning these priorities and objectives to adopt LC can be a barrier, particularly when more collaboration and communication are needed between project participants [36–38]. Numerous studies [11,39–41] indicate that relying on numerous subcontractors in construction projects hinders LC adoption due to the difficulty of aligning them in each phase[12].

One study explored that the absence of supply chain integration is a barrier to LC adoption [42], because it hinders the efficient flow of materials and information, resulting in a deficiency of one of the principles of LC [11].

LC requires a proactive and systematic approach to planning, scheduling, and coordination [39]. Meanwhile, the traditional construction industry generally has problems with planning, communication, and decision-making due to the complex organizational hierarchy [40,43]. Furthermore, there is a lack of involvement from contractors and specialists during the initial planning and design stages [12,44]. The circumstances mentioned above pose challenges to the successful execution of LC implementation [29,31].

Within the organizations, the absence of effective leadership and a lack of commitment from top management constitute significant barriers to implementing LC ideas [30]. Therefore, in order to successfully incorporate LC principles, it is imperative that leadership at all levels of the organization actively supports the transition to the LC methodology [45] and builds an environment that encourages ongoing improvement [28,32].

LC also demands a long-term commitment to innovation and change [25], but some construction organizations refuse continual improvement and innovation due to their fear of change and focus on short-term gains [28]. LC, on the other hand, requires a system for measuring performance and continuous improvement. Consequently, his absence constitutes an obstacle to adoption [12,13,31]. Further, the absence of financial assistance [40], suitable materials [35,46], and equipment [23,44] for LC are good reasons not to adopt it. The adoption of LC is also influenced by external factors, such as inflation [31], which puts additional pressure on companies' plans to implement new management techniques, such as LC [45].

Another significant barrier is the lack of knowledge about integrating LC into public procurement procedures [30], where government projects make up a significant portion of the construction industry, and incorporating LC into these projects can result in significant efficiency improvements [40]. However, a lack of knowledge and experience in aligning the LC's principles with public procurement processes can hinder its implementation [31].

Inconsistent government policies are a further barrier to LC implementation [11,12,47]. Furthermore, the lack of supportive government laws and regulations can be a significant barrier to implementing LC [40] because construction firms require a legal framework that encourages them toward LC methods [31,41]. Adopting LC without these supporting regulations can be slow [29]. Table 1 lists the main LC barriers highlighted in the literature.

2.3. Lean Construction and Jordanian Construction

Researchers interested in LC in developing countries have focused on studying its applicability, feasibility, level of awareness among construction professionals, barriers to adoption, sources of construction waste, and the most efficient LC ways to dispose of it [48].

Jordan, as a developing country, researchers have engaged in some research related to LC based on their agreement that the adoption of a change philosophy within Jordan's construction sub-sector is of the highest priority in order to increase sustainability, address issues related to limited resources, address organizational challenges, and meet the demand for innovation and modernization [15]. This change may lead to a more prosperous and resilient future for Jordan's construction industry [6].

Out of these, only four contributions were found in recent years that addressed LC in the Jordanian construction industry [9,13,14,27]. One of these studies illustrated the conformance between the first-grade Jordanian contractors regarding the LC and claimed that the contracting companies agree with some of the LC procedures; however, there is no indication of widespread application at the company level [14]. The limited widespread use of LC goes back to the need for a suitable culture, an understanding of continuous improvement, and adequate training within companies [9].

Another study illustrated that a lack of understanding among Jordanian stakeholders regarding lean principles is the main reason that hinders the ability to effectively implement lean in the construction logistics process [27].

Moreover, a study examined the primary barriers to LC acceptance and adoption in the Jordanian construction industry; the results of this study indicate that insufficient care and support from top management, limited awareness of LC principles, inadequate training, and a lack of transparency are the main barriers that impede the adoption of LC [13].

3. Material and methods

3.1. Overall aproach

This research aims to identify critical barriers to LC implementation in the Jordanian building sub-sector and develop a theoretical framework to address them. The research team followed the procedure illustrated in Figure 1 to achieve these goals. An in-depth systematic literature review was conducted to identify the barriers to LC implementation and adoption. They were accounted into 27 barriers that were

Table 1
Barriers to LC Implementation

Code	Barriers	Source
B1	Lack of knowledge about LC concepts (approaches).	[13,23,25,29–32,34,36,40,41,44–46]
B2	Lack of knowledge about LC implementation.	[13,23,25,29,31,32,34–36,41,44,45]
B3	Lack of employee training and continuous improvement in LC.	[11–13,25,29,31,35,36,40,41,44,45]
B4	Unskilled labor and low level of education of the site foreman.	[13,29,30]
B5	Contractors and specialists rarely involved in the planning and design phase.	[11,12,32,41,43,44]
B6	Inadequate pre-planning.	[5,12,13,29–32,36,43]
B7	Slow decision-making as a result of complex organization hierarchy.	[11–13,28–32,38,40,43,44]
B8	Lack of supply chain integration.	[11–13,25,41,42]
B9	Poor communication and coordination system inside the company and among the construction participants.	[11,12,23,25,29–32,34–38,43]
B10	Dependence on many subcontractors.	[11,12,34]
B11	Lack of knowledge about including LC within the public procurement procedure.	[30,31,40,41]
B12	Inconsistent governmental policies (not constant and steady) over time.	[12,30,31,34,38,40,44,47]
B13	Lack of supportive government laws and regulations that help implement LC.	[11–13,23,25,28,29,31–34,36,40,41,43,44]
B14	Lack of long-term commitments to innovation and change within the company.	[11–13,23,25,28,29,31,32,41,43,44]
B15	Lack of support from top management.	[11,12,23,25,28–38,44]
B16	Stick to the old ways and refuse to use new ideas.	[13,23,25,29–31,33–37,41,44]
B17	Labor considers LC too complex.	[13,23,25,29,31,33,35,45]
B18	Inaccurate and incomplete designs.	[11,12,23,29,34,35,45]
B19	Lack of software advancement that helps in implementing LC.	[11,12,31,35,36,43–45]
B20	Difficulty nature of construction industry.	[12,13,30,33,43,47]
B21	Limited use of off-site construction techniques and prefabrication.	[13,30,35]
B22	Inadequate performance measurement system.	[12,13,28–32,44]
B23	Inflation.	[31,35,43,45]
B24	Lack of funding to start the implementation of LC in the company.	[13,23,25,29–31,33–36,40,41,43–45]
B25	Inadequate equipment to implement LC methods.	[11,12,23,33–35,44]
B26	Scarcity of materials suitable for LC implementation.	[11,12,23,33–36,43,44]
B27	Lack of motivation for the employees to learn about LC.	[11–13,28,29,31,38,43,45]

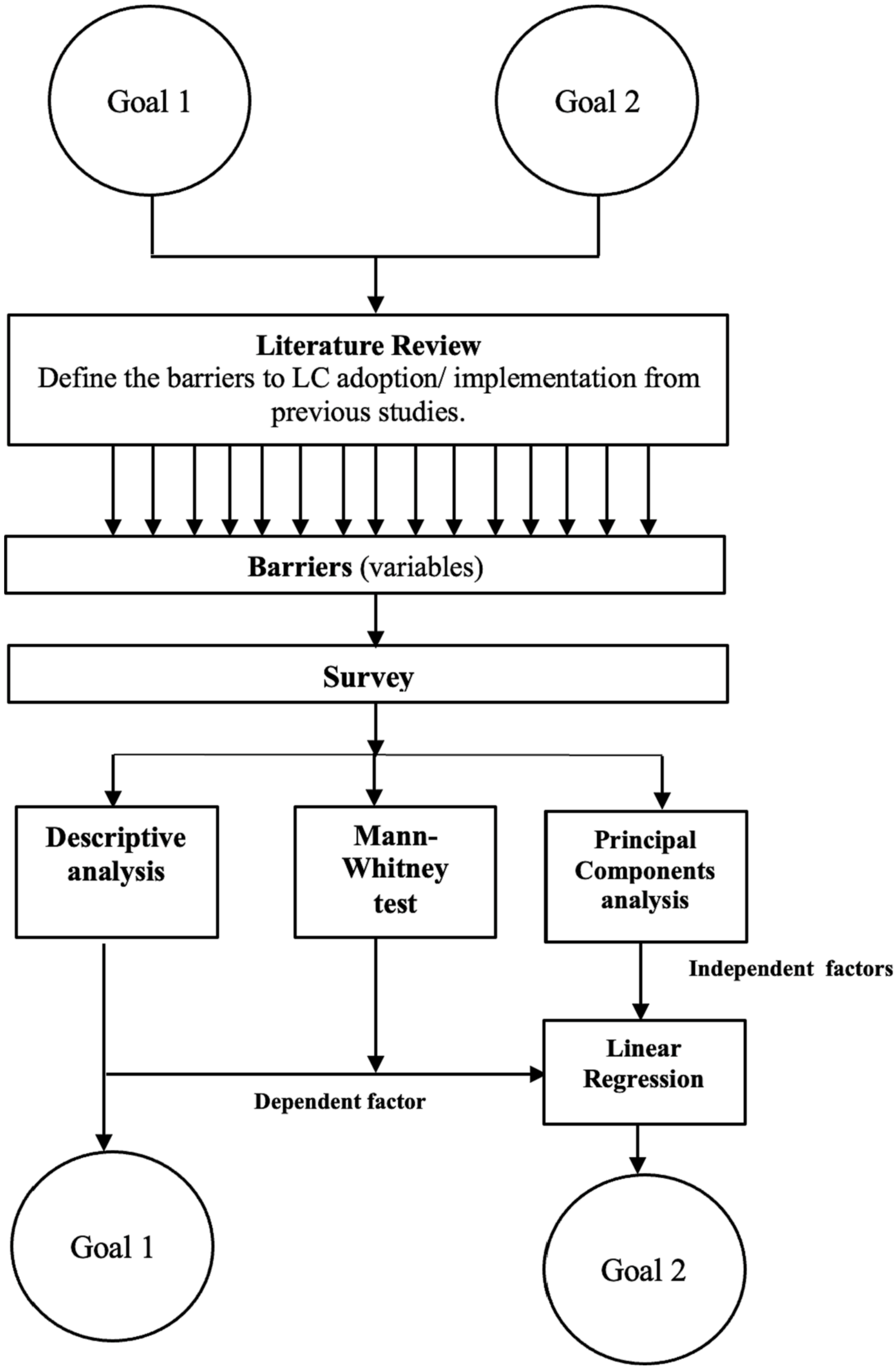

Figure 1. Research Process.

the foundation for developing a questionnaire.

The questionnaire is a widely structured research method with pre-determined questions seeking participant data and insights [49]. The questionnaire was validated and distributed to professionals working in first-class construction companies (Contractors) and first-class engineering companies (Consultants). These companies were categorized according to the classification system established by the Jordanian Construction Contractors Association (JCCA) and the Jordanian Engineers Association (JEA). The data analysis of the returned questionnaire included descriptive analyses and the Mann-Whitney test to explore if there is a significant difference between the opinions of the professionals who practice and do not practice the LC.

Subsequently, the most critical barriers to LC implementation in the Jordanian building sub-sector were identified (Goal no.1). A principal component analysis (PCA) was conducted to reduce the barriers and find the underlying factors that hinder LC implementation in the Jordanian building sub-sector. The results of these analyses served as input to linear regression analysis. The linear regression analysis aimed to find the relationships between the most critical barriers (dependent factors) and the underlying factors obtained from the PCA. The conclusions of these analyses were the foundation for defining a theoretical framework to implement LC in the Jordanian building sub-sector (Goal no. 2).

3.2. Survey

A questionnaire was defined to capture information about LC and the barriers to its implementation in the Jordanian building sub-sector. The questionnaire was divided into two sections. The first section contains a characterization of the respondents, including the type of company in which they work, the kind of building projects undertaken by these companies, as well as their experience, education levels, size of the companies, involvement in international projects, and public (government) projects and their familiarity with LC. The second section included 27 barriers to LC implementation based on a literature review. This section concerns how professionals respond to these barriers using the 5-point Likert scale to know the professional perception of each barrier. A Likert scale is a standard evaluation type with five or seven points to rank the variable from high to low [5: strongly agree, 4: agree, 3: neutral, 2: disagree, 1: strongly disagree] [50].

Later, six construction management academicians were asked to validate the questionnaire. They were chosen not only because they have published in LC topics but also because they work as consultants for construction companies. Following these academicians' comments and feedback, the questionnaire was modified and improved into an English and Arabic online Google Form that could be completed in 15-20 minutes. The targeted population of this research were Jordanian professionals who worked in construction (contractors) and engineering (consulting) companies with the first classification. The contact list of this targeted sample was compiled through JCCA and JEA's databases. Subsequently, the online Google Form questionnaire was directly distributed to them via email or a LinkedIn message. This data-gathering effort yielded 207 completed questionnaire forms via the Google Forms platform, representing a 53% response rate.

3.3. Data Analysis Techniques

The collected data were clustered to clarify which inferential statistical analysis served the research objectives, as well as to verify the validity and reliability based on appropriate tests. While validity focuses on evaluating suitability and accuracy, reliability focuses on the stability and consistency of test scores [51]. The validity of this research was achieved through factor analysis to see if the factor load is strong, weak, or cross-loading. The reliability of the main sections of the questionnaire was evaluated using Cronbach's Alpha coefficient. The coefficient must be between 0 and 1; a higher value indicates good consistency [52]. The data were analyzed using IBM SPSS Statistics. The statistical analysis performed provided results according to (Figure 1): (1) descriptive statistics to identify the main barriers to implementing LC in the Jordanian building sub-sector (GOAL no. 1). In addition, the Mann-Whitney U test was used to analyze the influence of the level of familiarity with LC techniques on the identification of the main barriers. The Mann-Whitney U test is a nonparametric test to compare two independent groups [53,54].

Subsequently, a Principal Components Analysis (PCA) was performed to reduce the barriers into three components. This analysis aimed to identify the main components that influence the implementation of LC in the Jordanian building sub-sector. PCA reduced the barriers in this study in order to classify them into components based on the factor load [59]. The Bartlett's sphericity test (P) and the Kaiser-Meyer-Olkin measure (KMO) results determined the appropriateness of the dataset. Subsequently, the commonality test assessed overall adequacy, indicating whether selected factors sufficiently account for the variance [55]; if a factor registered a commonality test value below 0.7, it was excluded, prompting a repetition of the PCA analysis without that factor. This iterative process continued until all aspects in the commonality test exhibited values exceeding 0.7.

Next, the KMO and Bartlett's sphericity test (P) were rechecked. Factors were grouped into components based on eigenvalues and the varimax rotation option in PCA [55].

To perform the PCA, the three main barriers were excluded. The reason was to determine the influence of the three components obtained from the PCA over these three main barriers; then three linear regression analyses were conducted (one per each main barrier). Linear regression is a statistical technique used to model the relationship between a dependent and one or more independent variables [56]. This analysis was used as a foundation to discover a link between the barriers and define a theoretical framework based on them (GOAL no. 2).

4. Results

This section presents the results of the recommended test from the previous section. Firstly, the Cronbach's Alpha coefficient value for all questionnaire items is 0.917, which is high and acceptable based on [52].

4.1. Statistical Characterization

Table 2 depicts the characteristics of the Jordanian building professionals who participated in this research survey and who are employed by contractors (59%) and engineering firms (41%), have a civil engineering education (79%), and have the most experience with a variety of non-residential buildings (73%). Their experience was divided into two categories: less than ten years and more than ten years, with roughly equal proportions (58% and 42%, respectively). The companies in which they work range from micro to large. A total of 58% have fewer than 50 employees, and 42% have more than 50 employees. Sixty-five percent of the projects undertaken by these companies were in collaboration with the government to finish public projects. As the results shown in Table 2, these Jordanian building professionals have less awareness and familiarity with LC; only 18% of them practice the LC tools in their career, and the remaining of them (82%) do not practice it, but 35% of them are familiar with the term of LC through the book and research.

4.2. Main barriers in Jordanian construction industry

The importance of each barrier to implementing LC in the Jordan building sub-sector is gathered in Table 3, including the mean value and standard deviations (SD) for the entire sample. Those variables with a

Table 2
Jordanian building Professionals' characterization

	Frequency	Percent
Company Type		
Contractors/Construction Companies	122	59
Consultants/ Engineering Companies	85	41
Type of Construction Work		
Residential Building	55	27
Non Residential Building	152	73
Educational Degree		
Civil Engineer	163	79
Other Engineer	44	21
Years of experience		
Less than 10 Years	121	58
More than 10 Years	86	42
Company Size		
Less than 50 employees	120	58
More than 50 employees	87	42
% of Public Work		
Less than 50%	135	65
More than 50%	72	35
Involvement in International Projects		
Yes	103	50
No	104	50
Practice/ Did not Practice LC		
Practice LC	37	18%
Did not Practice LC	170	82%
Familiarity of LC between Professionals who do not Practice it		
Familiar	60	35%
Non Familiar	110	65%

Table 3
Descriptive analysis and Mann-Whitney -U test.

Code	Barriers	All(207)		Practice LC (37)		Do not Practice LC (170)		*P*-value
		Mean	SD	Mean	SD	Mean	SD	
B1	Lack of knowledge about LC concepts (approaches).	**3.91**	0.804	**3.95**	0.815	**3.90**	0.804	0.780
B2	Lack of knowledge about LC implementation.	**3.86**	0.876	**4.11**	0.737	**3.81**	0.897	0.070
B3	Lack of employee training and continuous improvement in LC.	**4.05**	0.893	**3.92**	0.924	**4.09**	0.885	0.286
B4	Unskilled labor and low level of education of the site foreman.	3.49	1.083	3.51	1.170	3.49	1.062	0.878
B5	Contractors and specialists rarely involved in the planning and design phase.	3.68	0.993	3.89	1.125	3.64	0.959	0.116
B6	Inadequate pre-planning.	3.71	1.089	3.89	0.994	3.66	1.114	0.301
B7	Slow decision-making as a result of complex organization hierarchy.	3.79	1.07	3.92	1.010	3.76	1.084	0.403
B8	Lack of supply chain integration.	3.4	0.96	3.68	0.915	3.33	0.953	**0.029**
B9	Poor communication and coordination system inside the company and among the construction participants.	3.67	1.088	3.86	1.058	3.64	1.097	0.270
B10	Dependence on many subcontractors.	3.52	1.214	3.65	1.296	3.49	1.198	0.358
B11	Lack of knowledge about including LC within the public procurement procedure.	3.64	1.028	4.05	0.743	3.54	1.061	**0.006**
B12	Inconsistent governmental policies (not constant and steady) over time.	3.44	1.155	3.68	1.156	3.38	1.157	0.117
B13	Lack of supportive government laws and regulations that help implement LC.	3.59	1.01	4.05	0.780	3.47	1.027	**0.002**
B14	Lack of long-term commitments to innovation and change within the company.	3.54	0.964	3.73	0.962	3.51	0.956	0.184
B15	Lack of support from top management.	3.53	1.056	3.51	1.044	3.55	1.055	0.837
B16	Stick to the old ways and refuse to use new ideas.	3.64	1.092	3.41	1.092	3.68	1.096	0.173
B17	Labor considers LC too complex.	3.22	1.003	3.32	1.082	3.18	1.001	0.576
B18	Inaccurate and incomplete designs.	3.36	1.047	3.70	1.051	3.27	1.048	**0.025**
B19	Lack of software advancement that helps in implementing LC.	3.45	1.008	3.51	1.193	3.43	0.966	0.477
B20	Difficulty nature of construction industry.	3.36	1.106	3.57	1.015	3.32	1.128	0.243
B21	Limited use of off-site construction techniques and prefabrication.	3.24	1.084	3.27	1.170	3.25	1.076	0.860
B22	Inadequate performance measurement system.	3.55	0.988	3.70	0.968	3.51	0.993	0.244
B23	Inflation.	3.37	1.111	3.59	1.013	3.31	1.137	0.219
B24	Lack of funding to start the implementation of LC in the company.	3.79	1.102	4.00	0.882	3.75	1.141	0.328
B25	Inadequate equipment to implement LC methods.	3.62	1.006	3.62	0.893	3.62	1.032	0.757
B26	Scarcity of materials suitable for LC implementation.	3.39	1.055	3.70	1.024	3.33	1.055	**0.025**
B27	Lack of motivation for the employees to learn about LC.	3.80	1.114	4.11	1.220	3.73	1.084	**0.019**

mean value above 3.0 are considered “accepted and important” [57].

Furthermore, Table 3 presents the importance assigned to each barrier based on the level of familiarity with LC techniques (professionals who are familiar with-practice LC, and professionals who are not familiar-do not practice LC). The Mann-Whitney U test is conducted to characterize whether significant differences exist (P-value < 0.05) between these two groups. These analyses provide a broader perspective on the main barrier to LC implementation in the Jordan building sub-sector.

Taking into account the whole sample, the main six barriers to LC implementation in the Jordanian building sub-sector are lack of employee training and continuous improvement in LC (B3), lack of knowledge about LC concepts (approaches) (B1), lack of knowledge about LC implementation (B2), lack of motivation for the employees to learn about LC (B27), lack of funding to start the implementation of LC in the company (B24), and slow decision-making as a result of complex organization hierarchy (B7);. In contrast, the least ranked barriers are limited use of off-site construction techniques and prefabrication (B21), and labor considers LC too complex (B17). These barriers are the most important for both professionals with and without practice in LC; however, professionals with practice in LC highlight as important barriers the lack of knowledge about including LC within the public procurement procedure (B11) and the lack of supportive government laws and regulations that help implement LC (B13).

Table 3 gathers the results of the Mann-Whitney U test. This technique analyzes whether the opinions of the two groups of professionals (with and without practice in LC) vary significantly (P-value ≤ 0.05). The results show no significant differences regarding the importance of most of the barriers. However, it is worth noting that the following barriers do exhibit slight variations: lack of supply chain integration (B8), lack of knowledge about including LC within the public procurement procedure (B11), lack of supportive government laws and regulations that help implement LC (B13), inaccurate and incomplete designs (B18), scarcity of materials that suitable for LC implementation (B26), and lack of motivation for the employees to learn about LC (B27) obtain statistical significance, observing that Jordanian building professionals who practice LC consider these barriers more important than professional who do not practice LC.

Additionally, it can be highlighted that Jordanian professionals who practice LC give higher importance to the barriers than non-practicing LC professionals, except for two barriers: lack of employee training and continuous improvement in LC (B3) and Stick to the old ways and refuse to use new ideas (B16). However, the Mann-Whitney test indicates no significant difference between the two groups concerning these two barriers.

4.3. Principal Component Analysis (PCA)

The PCA aims to reduce the barriers and find the underlying factors that collect them. PCA analyzes the correlations between variables to find the minimum number of dimensions that retain the maximum information from the barriers. The Kaiser-Meyer-Olkin (KMO) and Bartlett’s sphericity tests were performed to check whether the data was appropriate for PCA (KMO > 0.6 and $P < 0.05$ for Bartlett’s test). The commonality and correlation tests were also used to determine which barriers should be included in the PCA and which should be excluded [58]. Barriers with low correlation and a commonality test value below 0.7 were excluded [62]. This process continued iteratively until a list of barriers with good correlation and commonality value (value > 0.7) was achieved [59].

In this research, the PCA was performed without including the following barriers: lack of knowledge about LC concepts (approaches) (B1), lack of knowledge about LC implementation (B2), and lack of employee training and continuous improvement in LC (B3). These three barriers were excluded because they were highlighted as the most important barriers by both Jordanian building professionals; additionally, several authors consider the knowledge-related barriers as the first step toward LC adoption [60] and the foundation for proper knowledge and training of individuals and institutions to understand and implement LC principles [29]. Therefore, these three barriers were excluded from this test and considered dependent variables in the linear regression analysis and the suggested framework.

During the PCA, the following barriers were excluded due to their low commonality test values: B5, B6, B7, B8, B9, B10, B17, B18, B19, B20, B21, B22, B23, and B27. Table 4 shows the results of the KMO (0.778) and Bartlett's test of sphericity (*P*-value = 0) of the PCA. In addition, the commonality of the nine barriers included in the analysis was over 0.7, indicating a good correlation (Table 5).

Table 6 provides the scores for the nine barriers of the three principal components identified by the PCA based on the eigenvalues greater than 1. These three principal components explain more than 77% of the variance. The three principal components can be identified as follows:

- Principal Component 1 (PC1): "*Government barriers*". The PC1 explains 26.6% of the variance and represents the lack of support by government laws and regulations to encourage the implementation of LC in the Jordanian building sub-sector (B13), the inconsistent governmental policies over time that hinder a comprehensive implementation of LC (B12), and the importance of properly including requirements related to LC within the public procurement procedure (B11).
- Principal Component 2 (PC2): "*Attitude barriers*". The PC2 explains 25.527% of the variance and represent a lack of long-term commitments to innovation and change within the company (B14), a lack of support from top management (B15), and stick to the old ways and refusing to use new ideas (B16).
- Principal Component 3: "*Resource barriers*". The PC3 explaines 25.207% of the variance and represent a lack of funding to start the implementation of LC in the company (B24), inadequate equipment to implement LC methods (B25), and a scarcity of materials that are suitable for LC implementation (B26).

4.4. Linear Regression

Three linear regression analyses were conducted to study the influence of the three components obtained from the PCA over the three main barriers (B1: lack of knowledge about LC concepts (approaches), B2: lack of knowledge about LC implementation, and B3: lack of employee training and continuous improvement in LC).

Before beginning with linear regression, the correlation test between dependents and independent variables was conducted to determine whether there was any multicollinearity and indicate the correlation between variables. Table 7 describes the correlations between the three barriers (B3, B2, and B1) and the defined components (government, attitude, and resources) from PCA. The results indicate that the data have a small to medium correlation; some show significance at 0.01 and others at 0.05.

After confirming the correlation test results, the forward methods from linear regression analysis were used to create a model that describes the three dependent variables (B1, B2, and B3). As presented in Table 8, the three defined components (government, attitude, and resource and financial) explained 14.7%, 17.5%, and 18.9% of the variation in B1 (lack of knowledge about LC concepts (approaches)), B2 (Lack of knowledge about LC implementation) as dependent variables, B3 (Lack of employee training and continuous improvement in LC) respectively. These values give a sign with low to medium correlation; however, the *P*-value is less than the predetermined significant level of 0.05 for all three defined components (government, attitude, and

Table 4
KMO and Bartlett's test results

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		0.778
Bartlett's Test of Sphericity	Approx. Chi-Square	1200.769
	df	55
	Sig.	0.00

Table 5
commonality test

	Initial	Extraction
B11	1	0.779
B12	1	0.754
B13	1	0.716
B14	1	0.777
B15	1	0.801
B16	1	0.763
B24	1	0.780
B25	1	0.800
B26	1	0.791

Table 6
Total variance explained by different components and Rotated component matrix.

LC Barriers	Government	Attitude	Resources
B12: Inconsistent governmental policies (not constant and steady) over time.	0.846	—	—
B11: Lack of knowledge about including LC within the public procurement procedure.	0.835	—	—
B13: Lack of supportive government laws and regulations that help implement LC.	0.808	—	—
B16: Stick to the old ways and refuse to use new ideas.	—	0.866	—
B15: Lack of support from top management.	—	0.847	—
B14: Lack of long-term commitments to innovation and change within the company.	—	0.821	—
B26: Scarcity of materials suitable for LC implementation.	—	—	0.884
B25: Inadequate equipment to implement LC methods.	—	—	0.860
B24: Lack of funding to start the implementation of LC in the company.	—	—	0.786
Eigenvalues	4.131	1.572	1.258
Variance (%)	26.617	25.527	25.207
Cum. Variance (%)	26.617	52.144	**77.351**

Table 7
Correlation test.

Barriers	Correlation value (*r*)		
	B1	B2	B3
Government Component	0.137*	0.284**	0.268**
Attitude Component	0.259**	0.199**	0.292**
Resources Component	0.272**	0.259**	0.209**

B1: Lack of knowledge about LC concepts (approaches).
B2: Lack of knowledge about LC implementation.
B3: Lack of employee training and continuous improvement in LC.
*Correlation is significant at the level 0.05
**Correlation is significant at the level 0.01

Table 8
Regression Models for [B1, B2, and B3]

Statistics	B1	B2	B3
R	0.400	0.433	0.448
R sq.	0.160	0.187	0.201
R sq adjusted	0.147	0.175	0.189
Standard Error	0.743	0.796	0.805

B1: Lack of knowledge about LC concepts (approaches).B2: Lack of knowledge about LC implementation.B3: Lack of employee training and continuous improvement in LC.

Table 9
Partial Regression Coefficients

Model	Unstandardized Coefficient		Standardized Coefficients	T	*P*-Value
	B	SE	Beta		
B1: Lack of knowledge about LC concepts (approaches)					
Constant	3.908	0.052		75.713	0.000
Government component	**0.110**	0.052	0.137	2.126	0.035
Attitude component	**0.208**	0.052	0.259	4.023	0.000
Resources component	**0.219**	0.052	0.272	4.231	0.000
B2: Lack of knowledge about LC implementation.					
Constant	3.865	0.055		69.867	0.000
Government component	**0.248**	0.055	0.284	4.482	0.000
Attitude component	**0.175**	0.055	0.199	3.148	0.002
Resources component	**0.227**	0.055	0.259	4.099	0.000
B3: Lack of employee training and continuous improvement in LC					
Constant	4.053	0.056		72.484	0.000
Government component	**0.240**	0.056	0.268	4.275	0.000
Attitude component	**0.261**	0.056	0.292	4.648	0.000
Resources component	**0.187**	0.056	0.209	3.338	0.001

resource and financial), as shown in Table 9. Therefore, these three have significant effects on our three dependent variables.

Additionally, among the three defined components (government, attitude, and resources), the resource barriers had the most influence on B1: lack of knowledge about LC concepts (approaches), followed by attitude and government barriers based on B coefficient values (0.219, 0.208, and 0.110, respectively). At the same time, the government barriers had the most influence on the B2: Lack of knowledge about LC implementation, followed by resources, and attitude barriers with B coefficient values (0.248, 0.227, and 0.175, respectively). Moreover, the attitude barriers had the most influence on the B3: Lack of employee training and continuous improvement in LC followed by government, and resources barriers with B coefficient values (0.261, 0.240, and 0.187, respectively).

5. Discussion

This study used a set of 23 barriers, identified through an extensive review of relevant literature, to examine the primary barriers that hinder the adoption of LC in the building industry in Jordan and provide a theoretical framework based on these barriers.

These barriers were integrated into a questionnaire distributed to Jordanian construction professionals from construction companies/ contractors and engineering companies/ consultants of the first classification. The following section discusses the main results of this research and compares it with similar studies.

5.1. Principal barriers to LC implementation in the Jordan construction industry

It is apparent from the study findings that building professionals in Jordan have a limited understanding of LC. Merely 18% of them have utilized LC tools in their careers. This finding is consistent with previous Jordanian research [13,14,61], demonstrating that Jordan's understanding and application of LC have not progressed in the last years.

Accordingly, the study's findings highlight the primary barriers to LC adoption in the Jordanian building sub-sector for both Jordanian construction professionals who do practice LC and those who do not; the top three barriers include the "lack of employee training and continuous improvement in LC, lack of knowledge about LC concepts (approaches), and lack of knowledge about LC implementation". These three barriers are mostly linked to knowledge barriers and were emphasized by both developing countries [13,28,29,32,33] and developed countries [24,30].

Recent studies conducted in Jordan [13], Nigeria [29], Bangladesh [11], and Morocco [33] agreed with these results. They classified the lack of education and insufficient training of the workers as the second influence challenge to LC adoption after the lack of awareness about the LC. Moreover, a study in India clustered these barriers under the lack of knowledge to deploy the new system and considered it the most critical obstacle to LC [28].

Another study in Peru [32] also grouped these barriers under "collaboration, education, and implementation". It was argued that these grouped barriers had a more significant impact on starting LC implementation. On the other hand, a study in the UK ranked the lack of training of laborers as the most significant barrier hindering LC implementation, with 88% of professionals agreeing [24]. Therefore, gaining appropriate knowledge and understanding is essential to supporting any new culture and helping to encourage stakeholder engagement [61]. To achieve proper knowledge of LC, the academic community must work together to add the "Basics of Lean Building" to courses offered at local universities [41]. In addition, organizations need to develop a program that includes seminars and training courses [38].

Another barrier hindering LC in the Jordanian building sub-sector is the "lack of motivation for the employees to learn about LC," which came fourth in importance after the three knowledge barriers mentioned above. Many studies have identified this barrier as a significant challenge to LC adoption [11–13,29,31]. A good reason for the importance of this barrier is that when employees are motivated to adopt LC, they will drive the change from traditional management to LC philosophy and use their creativity to improve project efficiency and reduce waste, which are the main LC objectives [45].

Another significant barrier to implementing LC in the Jordanian building sub-sector is the "Lack of funding to start the implementation of LC in the company". Inadequate funding was cited as one of the most significant barriers to LC implementation by Bajjou and Chafi, 2018 [33], and Ahmed and Wong, 2020 [40]. Sufficient funding is essential for facilitating educational opportunities and organizing workshops to raise LC awareness. It is also useful for locating and purchasing any necessary materials for particular LC techniques [23,39].

Furthermore, "Slow decision-making as a result of complex organization hierarchy" was ranked as the fifth most problematic barrier. According to a study conducted in Qatar [44], the lack of decentralized decision-making would slow down material requests at the necessary time and lower employee empowerment, leading to difficulty in enrolling the LC in the construction company's system.

In addition to these results, there were no significant differences in opinion among Jordanian construction professionals who do and do not practice LC in their careers, with the exception of the following six barriers: "Lack of supply chain integration", "Lack of knowledge about including LC within the public procurement procedure", "Lack of supportive government laws and regulations that help implement LC", "Inaccurate and incomplete designs", "Scarcity of materials suitable for LC implementation" and " Lack of motivation for the employees to learn about LC". According to Table 3, these barriers were ranked higher in importance by Jordanian LC practitioners. This is due to the fact that their opinions are founded upon their practical knowledge, well-informed viewpoint, and experience in the LC.

An additional notable finding of this study is the utilization of PCA to identify three component barriers: government, attitude, and resource barriers. The naming of the components was determined by the interrelated attributes of the barriers they constituted. This result is consistent with a study developed in the UK [41]. The results of this study also identified human attitudes, financial and resource barriers, and government barriers as three of the six most important challenges to LC implementation.

The government component encompasses barriers such as inconsistent governmental policies (not constant and steady) over time, a lack of knowledge about including LC within the public procurement procedure, and a lack of supportive government laws and regulations that help implement LC.

Government barriers significantly influence the implementation of LC, serving as crucial elements that can either support or impede progress. This finding aligns with a previous study [23] highlighting supportive government regulations as enablers for effective LC implementation. On the other hand, a recent study published in Brazil [28] supported the importance of government barriers and how numerous regulations and laws can impede the progress of new concepts and techniques and hinder the capability of construction companies to carry out practical principles and practices of new techniques such as LC.

The attitude component represents challenges related to sticking to the old ways and refusing to use new ideas, a lack of support from top management, and a lack of long-term commitments to innovation and change within the company. A study in Zimbabwe [12] discussed the significant consequences of these barriers for adopting LC.

Attitude barriers limit effective communication among stakeholders, leading to increased conflicts and restricting innovation and creativity [30,44]. This also has a negative impact on the implementation of LC, which relies on effective communication and includes innovation [18]. Additionally, this result matches the results of a study in Saudi Arabia (KSA) that put the attitude group at the top and focused on the impact of traditional ways as the most critical barrier [38].

Finally, regarding the resource component, this encompasses aspects related to the scarcity of materials suitable for LC implementation, inadequate equipment to implement LC methods, and a lack of funding to start the implementation of LC in the company. This barrier group greatly restricts organizations from fully adopting and incorporating LC principles. This highlights the importance of allocating resources strategically and making investments to overcome these barriers and learn the advantages of LC. A study conducted in Lebanon supported these findings and identified financial resource obstacles as the primary obstacles to implementing LC [35].

The results of another study conducted in the Gaza Strip revealed that financial resource constraints are among the primary barriers to implementing LC across various organizations. The study also suggested that it is essential to have adequate funding to provide the resources that are required for the successful implementation of LC [31].

5.2. Framework's Proposal

This study aims to define a theoretical framework to implement LC in the Jordanian building sub-sector. This framework, represented in Figure 2, is organized in a pyramidal shape with three levels or steps in implementing LC. The three levels of the pyramid represent the three most important barriers to implementing LC that need to be overcome to enhance the LC implementation in the Jordanian building sub-sector [18,23,39,63]:

- Level 1: Lack of knowledge about LC concepts and approaches
- Level 2: Lack of knowledge about LC implementation, and
- Level 3: Lack of employee training and continuous improvement in LC

The first level of the pyramid focuses on enhancing understanding of LC concepts and approaches, serving as the pyramid's foundation. This level is crucial to achieving a strong comprehension of LC principles. Then, it is also vital for professionals to understand its philosophy and application and to tackle the subsequent barriers effectively [63].

The second level is all about learning how to implement LC into action. This level illustrates the importance of moving from theoretical understanding to real-world application. Professionals have to figure out

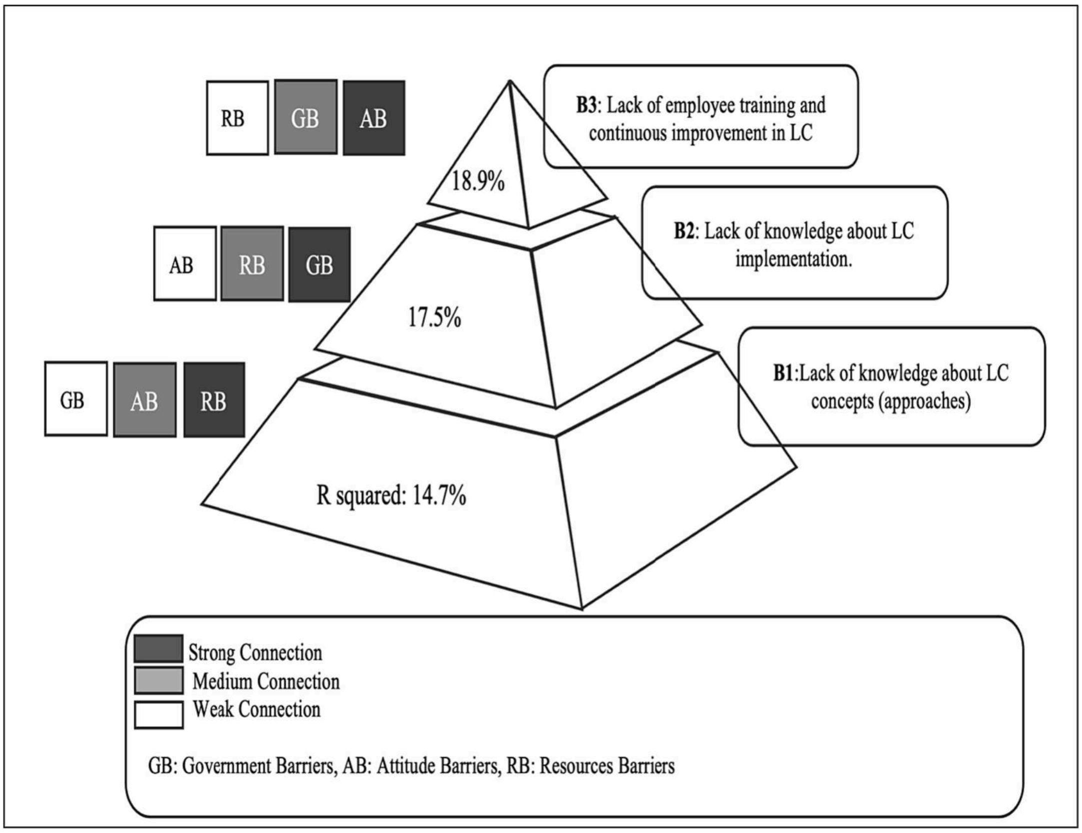

Figure 2. Proposal of the theoretical framework to LC implementation in the Jordanian building sub-sector.

how to use LC principles in real-life construction situations, which can be hard and complicated [18].

The third level focuses on training and continuous improvement. This level shows the need for continual training and development, reflecting the nature of LC. If LC practices are not continuously improved, their efficacy may eventually decline. This level highlights how essential it is for professionals to stay updated on continuous improvement and training [64].

Additionally, according to the results of the statistical analyses, each level needs to make major efforts to manage some of the three components identified: government, attitude, and resource barriers. The principal aim of integrating these components into the framework is to address their contributions to each level of the knowledge framework.

The importance of these three components (government (GB), attitude (AB), and resource (RB) barriers) varies depending on the different levels of the framework. This variation is determined by the individual contribution of each component in the importance of each level (results of the B coefficient in Table 9). The subsequent subsections examine each level of the pyramidal knowledge framework and the components that affect it.

5.2.1. Level One: Lack of knowledge about LC concepts (approaches)

Understanding LC concepts (approaches) is fundamental to LC knowledge and represents the first level of the suggested framework. It refers to understanding the main objectives of LC, its tools and techniques, and the benefits of their application [29–31,44].

The lack of this knowledge is the first thing that must be overcome in the suggested knowledge framework, and the three components (government, attitude, and resource barriers) affect it with different strengths.

This level, focused on understanding LC concepts (approaches), is strongly influenced by resource barriers (RB) and slightly influenced by attitude and government barriers. The main efforts need to be focused on increasing the resources to bring an understanding of LC concepts to the Jordanian building subsector. Resources are related to aspects such as financial resources, time availability, and access to training and educational materials [45]. Insufficient resources can make it difficult for individuals and organizations to acquire the knowledge and skills needed to implement LC effectively [39]. Organizations can take specific actions to overcome these resource barriers and gain an understanding of LC concepts. Firstly, they can allocate financial resources for implementing training programs and engage LC specialists or consultants from within the organization. A study conducted in Bangladesh [43] emphasized that acquiring knowledge about LC concepts may require high costs, primarily due to the expenses related to training programs and workshops.

Secondly, it is crucial to guarantee that employees have sufficient time to engage in training programs and acquire new knowledge. Once the necessary resources become accessible, organizations can redirect their focus toward addressing attitude barriers and seeking government support. Attitude barriers hinder the complete understanding of LC principles and occupy the second position. These barriers impede individuals from accepting new ideas and altering their habits [33]. Organizations can overcome this barrier by promoting a favorable attitude towards LC among their employees and developing a willingness to acquire and accept its principles.

Government barriers are the final significant component contributing to the lack of understanding of LC concepts. These barriers include complex regulations and policies that limit the spread and acceptance of LC practices [30]. To overcome governmental barriers, industry stakeholders and policymakers must engage in collaborative efforts to simplify procedures, modify regulations, and provide support for LC [13].

5.2.2. Level Two: Lack of knowledge about LC implementation.

Knowledge regarding the implementation of LC refers to an in-depth understanding of how to integrate LC tools and techniques within the organization to maximize the advantages gained from LC. Various studies have identified the lack of this specific knowledge as a significant barrier to LC adoption [25,32,34,36].

This level, focused on understanding LC implementation, is strongly influenced by government barriers (GB) and slightly influenced by resource and attitude barriers.

Government policies and regulations significantly impact the execution of public construction projects in various ways. If government policies do not encourage the adoption of LC practices, building professionals may hesitate to invest time and resources in learning how to implement LC effectively [13].

Effective communication of the benefits of LC to government officials and the provision of examples of successful cases can help decision-makers overcome governmental barriers and improve their understanding of LC implementation. This action, in turn, will lead to increased government support [18].

The resource barriers are the second barrier that discourages people from knowing how to implement LC. Organizations can allocate resources to help implement LC if they have gained confidence that government rules will not impede its implementation. These resources include budgeting for training, technology, and lean tools [11]. The final barriers that contribute to this level are attitude barriers. To overcome these barriers, the organization must resume its efforts to create a supportive culture that values continuous improvement, collaboration, and a willingness to adopt new approaches [65]. By recognizing and addressing attitude barriers, organizations can enable a positive environment by facilitating knowledge acquisition on implementing LC concepts.

5.2.3. Level Three: Lack of employee training and continuous improvement in LC

Employee training focuses on educating professionals, including workers and managers, about the LC concepts (principles), tools, and practices [39]. The key to LC's success is not only employee training but also ongoing systematic efforts [63,64].

After acquiring the necessary knowledge of LC concepts, understanding how to implement them, and completing the first two levels of the knowledge framework, it becomes essential to start training employees. Training and continuous improvement in LC knowledge are shown at the top of the frame.

This level, focused on guaranteeing training and continuous improvement, is strongly influenced by attitude barriers (AB) and slightly affected by government and resources barriers.

Attitude barriers relate to individual beliefs and behaviors. When an employee hesitates or refuses to adopt new concepts, it becomes difficult to involve them in training programs [23,63,66,67]. Encouraging a supportive organizational culture that prioritizes open communication and recognizes the advantages of adopting new approaches can help reduce hesitancy [18]. In addition, customizing training programs to target individual problems specifically and highlighting the tangible benefits of the LC can promote employee engagement and facilitate the integration of its concept and practice [62]. When the employees agree with LC principles and receive training, this encourages enhanced interdepartmental cooperation and cultivates a positive connection with the government [23].

Consequently, the focus must be on government barriers, which include regulatory and governmental processes, both of which tend to hinder the implementation of training and improvement projects. A study in Malaysia [40] recommended that the government must encourage LC adoption and support the training program.

Finally, resource barriers must be overcome to facilitate employee training by guaranteeing sufficient funding, technology, and qualified staff for training and improvement [33,63]. By systematically addressing these barriers, organizations can establish a solid basis for practical employee training and long-term improvement in their operations.

6. Conclusions

6.1. Theoretical Contributions

Given the global impression and demonstrated effectiveness of LC, it became imperative to study its implementation through the level of awareness and barriers in the different countries, particularly in countries where this methodology remains unfamiliar or lacks formalized application. In Jordan, the awareness of LC practices appeared very low; only 18% of building industry professionals practice LC in their careers. Based on an extensive literature review, 27 barriers to implementing LC were identified and modified to achieve this research's first objective.

The findings indicate that the primary barriers influencing the adoption of LC practices in the Jordanian building sub-sector are primarily associated with knowledge-related factors. These include insufficient employee training and a lack of continuous improvement in new techniques, such as LC. Additionally, there is a lack of understanding regarding the concepts and approaches of LC and a lack of knowledge on how to implement these practices effectively. In addition to the knowledge barriers, there are more essential barriers; the lack of a motivation system to encourage employee engagement in learning about LC and funding issues poses a challenge to implementing LC and establishing a comprehensive motivation and training system. Furthermore, the complex organizational hierarchical structure slowed the decision-making process. There is a shared perception concerning these outcomes among professionals who engage in LC practices and those who do not engage in such practices. Despite the minor variations, there is a broad consensus among them regarding the significance of knowledge barriers and how crucial it is to overcome them.

The contributions mentioned above are associated with the second objective of this research, which involves the development of a theoretical framework. The proposed framework attempts to organize the barriers to knowledge in a hierarchical structure with a logical order. It then examines the interrelationships between these and other grouped barriers: government, attitude, and resources.

The findings suggest that to foster an understanding of lean concepts in the Jordanian building sub-sector, it is imperative for building companies in Jordan to allocate financial and resource investments towards workshops and various courses. Subsequently, these companies should continue utilizing these resources to implement effective LC practices. Additionally, seeking government support is recommended to strengthen the implementation. After acquiring this knowledge, Jordanian building companies must incentivize employees to engage in training programs that help continuous improvement. In conclusion, this comprehensive framework generates a synergistic outcome, fostering an environment conducive to overcoming barriers to LC and gaining its benefits.

The findings of this study are helpful to decision-makers in the building sub-sector of Jordan, providing a clear understanding of the barriers that may hinder the start of the implementation of LC. The information from the essential barriers in the suggested framework gives them a structured and conceptual foundation to start working on the essential barriers to implementing LC. Additionally, the framework may serve as a guide for researchers to develop this framework to include the enablers of aLC.

6.2. Practical Recommendations

To successfully address the barriers associated with the implementation of LC in the sub-building sub-sector of Jordan, it is highly advisable to commence efforts towards utilizing and developing the proposed knowledge framework. The proposed framework would function as a systematic approach to disseminate crucial LC knowledge and optimal practices among various stakeholders involved in the building sub-sector in Jordan. As a result, it enhances the level of expertise in implementing LC. On the other hand, the government and universities must promote this knowledge in Jordan by incorporating LC courses into academic programs and hosting government-sponsored workshops and seminars.

6.3. Limitations

The first limitation of this research is that it examined the barriers to LC only in the building sub-sector in Jordan (both residential and non-residential) and did not consider the other construction types. The second limitation of this research was that it focused on implementing LC through the barriers that hindered it and did not delve into the enablers of its implementation. In addition, the investigation of the barriers was in implementing LC generally. It did not investigate the barriers of specific LC tools, such as the Last Planner System, Kanban, Kaizen, etc. Thirdly, this research relies entirely on the survey method, even though it is a common method for examining a different variable or factor. Finally, the suggested knowledge framework did not include the barriers about managerial and technical aspects because the analysis results did not include them.

6.4. Future Research

The following recommendations could guide future research endeavors:

- Additional research covering all construction areas (infrastructure, roads, bridge steel construction, etc.) is required to raise awareness of LC in Jordanian construction.
- More studies must delve into the enablers of LC implementation in the Jordanian construction sector to understand these management techniques comprehensively.
- The framework's validation could be done through case studies or structured interviews with Jordanian construction professionals.
- The relationship between the proposed knowledge framework and the managerial and technical barriers should also be investigated.

CRediT authorship contribution statement

Esraa Hyarat: Data Collection, Data analysis, Writing, Original draft. **Laura Montalbán-Domingo:** Supervision, Data analysis, Review and Editing. **Eugenio Pellicer:** Supervision, Review and Editing.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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